

Hydrologic Analysis and Preliminary Watershed Stabilization
Project: Hazel Creek, Red Creek Basin, Wyoming

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by

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HYDROLOGIC ANALYSIS AND PRELIMINARY WATERSHED
STABILIZATION PROGRAM: HAZEL CREEK, RED CREEK BASIN, WYOMING

INTRODUCTION

Hazel Creek is a 3.20-square-mile sub-basin located within the 109-square-mile Red Creek river basin in southwestern Wyoming (Fig. 1). It is representative of much of the north and northwest draining portions of the Teepee Mountains, which make up over 25 square miles of the Red Creek river basin. The Hazel Creek watershed produces surface runoff causing stream channel erosion in Hazel Creek and its tributaries. Surface soil loss (interrill and rill erosion) results from concentrated surface runoff in the middle and lower Hazel Creek basins. Hazel Creek contributes to the peak flows, bank erosion, and sediment load in the main channel of Red Creek.

The purpose of this report is to provide to the Salt Wells Resource Area a detailed analysis of the watershed condition of Hazel Creek and to provide quantitative runoff and erosion estimates for the various land types within the basin. In addition, alternative potential projects for reducing runoff and erosion, and improving forage production in Hazel Creek are reviewed. Three projects recommended for immediate implementation are:

1. Maintain and raise the existing dam on Hazel Creek main stem.
2. Control the gully head cut at the lower end of the upper meadow on Hazel Creek, main stem.
3. Implement a prescribed burn in the upper meadow on Hazel Creek, main stem.

Other projects considered include:

1. Maintenance of existing dam on West Fork Hazel Creek.
2. Channel realignment and retention structures on East Fork Hazel Creek.
3. Channel realignment, upper meadow, Hazel Creek main stem.

BACKGROUND

The Wyoming portion of Red Creek, of which Hazel Creek is a tributary, contributes approximately 84,000 tons/year of sediment (1.3 tons/acre/year) to the Green River below Flaming Gorge Reservoir. Mean annual runoff at the mouth of Red Creek is 6,200 acre-feet (0.8 inches). A watershed management plan developed by the Rock Springs District of the Bureau of Land Management (USDI, 1981) develops management objectives, policies and certain project alternatives for reducing runoff and erosion in Red Creek and improving forage production and range condition. The overall erosion condition of Red Creek was determined earlier by the Soil Conservation Service (SCS, 1979).

The Hazel Creek Watershed Stabilization project was conceived in 1982 as a pilot project to demonstrate methods of watershed analysis which would be useful in the design of watershed projects recommended in the Red Creek Watershed Management Plan.



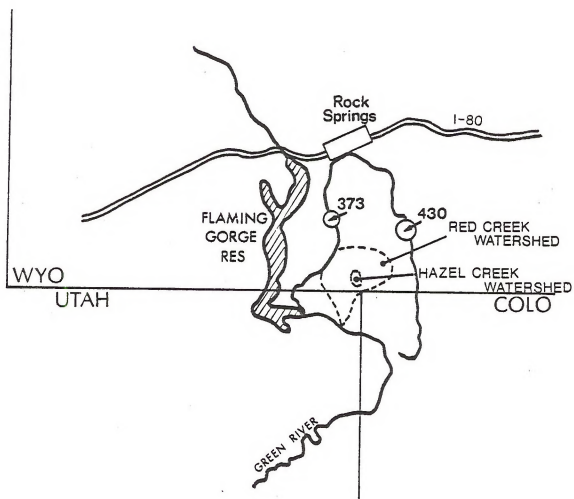


Figure 1. Hazel Creek location map.



WATERSHED DESCRIPTION AND CONDITION

Physiography

Hazel Creek is a 3.2-mi² tributary to Red Creek (Fig. 2) located in the center of the Red Creek Basin, it drains northward from the Teepee Mountains. Basin relief is approximately 1,800 feet with maximum and minimum elevations of 8,509 and 6,680 feet, respectively.

Geology and Soils

The upper or main body of the Wasatch Formation dominates the geology of Hazel Creek. The bedrock is fine- to coarse-grained gray sandstone and interbedded red and gray mudstone. On the east side of Hazel Creek the landscape has weathered to badlands. Alluvium is contained in the stream bottoms to approximately 7,100 feet elevation. Shallow colluvial deposits are common at the higher elevations above the stream channels and colluvium has formed interfluvial terraces and benches in the middle portions of Hazel Creek.

The Rock Springs District soil scientist provided a map of soil complexes for the Hazel Creek drainage (Fig. 3). Hydrologic soil types have been classified as follows:

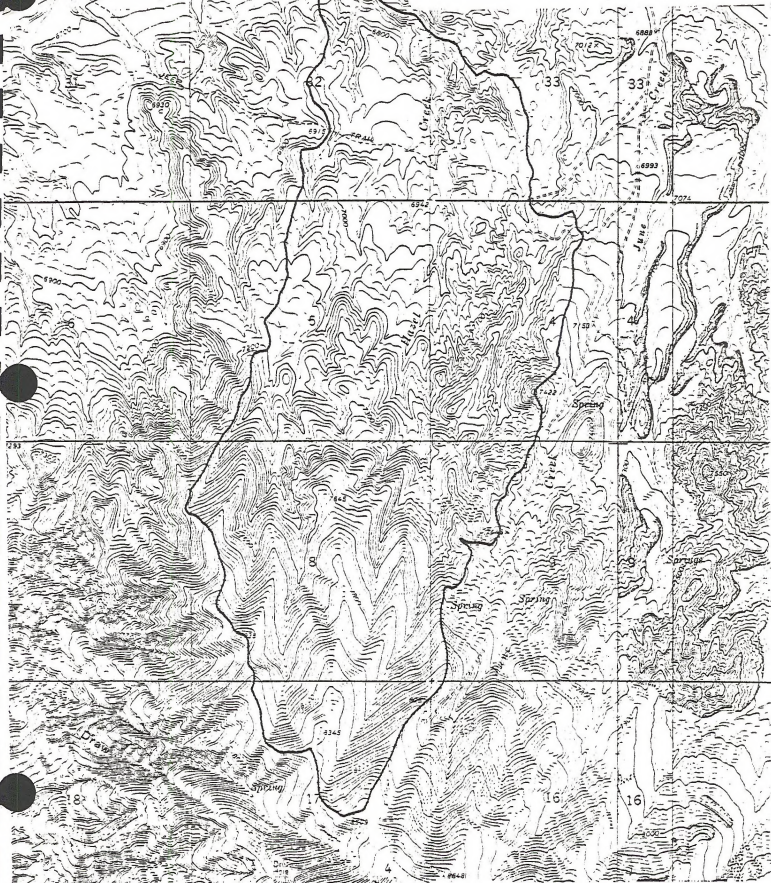
<u>Map Code</u>	<u>Name</u>	<u>Hydrologic Soil Group</u>	<u>Erodibility</u>
501	Tisworth Fine Sandy Loam	C	Moderate
505	Cragosen-Brownsto-Thermopolis Complex	D	High
509	Red-Creek-Thermopolis Complex	D	High
524	Brownsto-Fiveoh Complex	B	Moderate
526	Thermopolis-Rock Outcrop Complex	D	High
709	Teemat-Teeler-Southace Complex	B	High
R4	Rock Outcrop-Redwash Complex	D	Very High

The hydrologic soil groups (A,B,C,D) refer to the relative degree of runoff potential, with soils classified as A having a very low runoff potential and those classified D having a very high runoff potential.

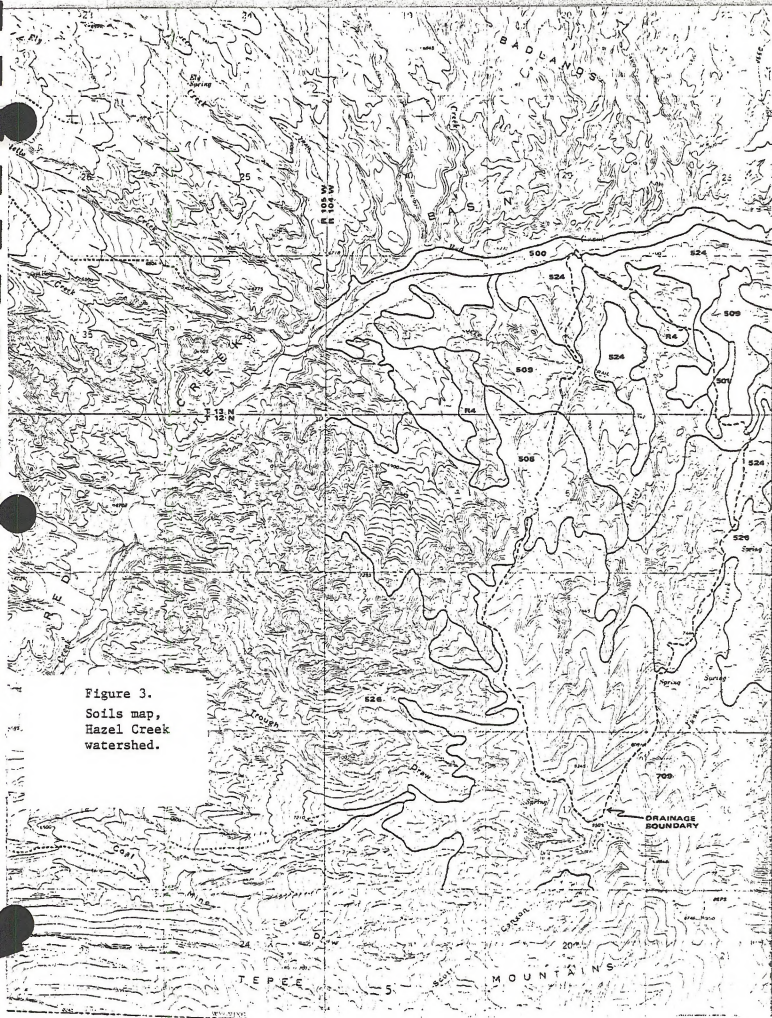
Vegetation and Hydrologic Condition

Two major vegetation types occur in the Hazel Creek watershed. The sagebrush-grass type is dominated by black sagebrush and occurs throughout the upper one-third and on the alluvial and colluvial flats in the lower two-thirds of Hazel Creek. The second major type is juniper which occurs on the ridges and steeper slopes throughout the middle and lower portions of the watershed. Sparsely-vegetated badlands and rock outcrops also occur in the watershed, particularly in the East Fork.











Range site descriptions, corresponding to the range site map codes in Figure 4, are given below.

<u>Map Code</u>	<u>Range Site Description</u>	<u>Precipitation Zone (inches)</u>
LY 10F	Loamy range site Fair condition	10 - 14
SL 10P	Saline lowland range site Poor condition	10 - 14
SWB 10G	Shallow breaks range site Good condition	10 - 14
VS 10G	Very shallow range site Good condition	10 - 14
25% RO	25% rock outcrop	10 - 14
75% VS 10F	Very shallow range site Fair condition	10 - 14

(Artr = sagebrush-dominated cover type;
JUOS = juniper-dominated cover type.)

Hydrologic condition, as defined for SCS rainfall-runoff determinations, is classified as:

<u>Percent Watershed Cover*</u>	<u>Hydrologic Condition Class</u>
0 - 30	Poor
30 - 70	Fair
70 - 100	Good

Most of the Hazel Creek drainage is in fair hydrologic condition. The stream bottoms in the upper sub-basins are in good hydrologic condition where gullies are not active. Much of the juniper vegetation type in the lower one-third of the basin falls into the poor hydrologic condition class, because of the large percentage of rock and bare soil.

Sub-Drainage Characteristics

The following four sub-drainage areas were selected and delineated for hydrologic analysis purposes:

*Includes basal area of forbs and grasses, basal and crown area of shrubs and trees, and litter.



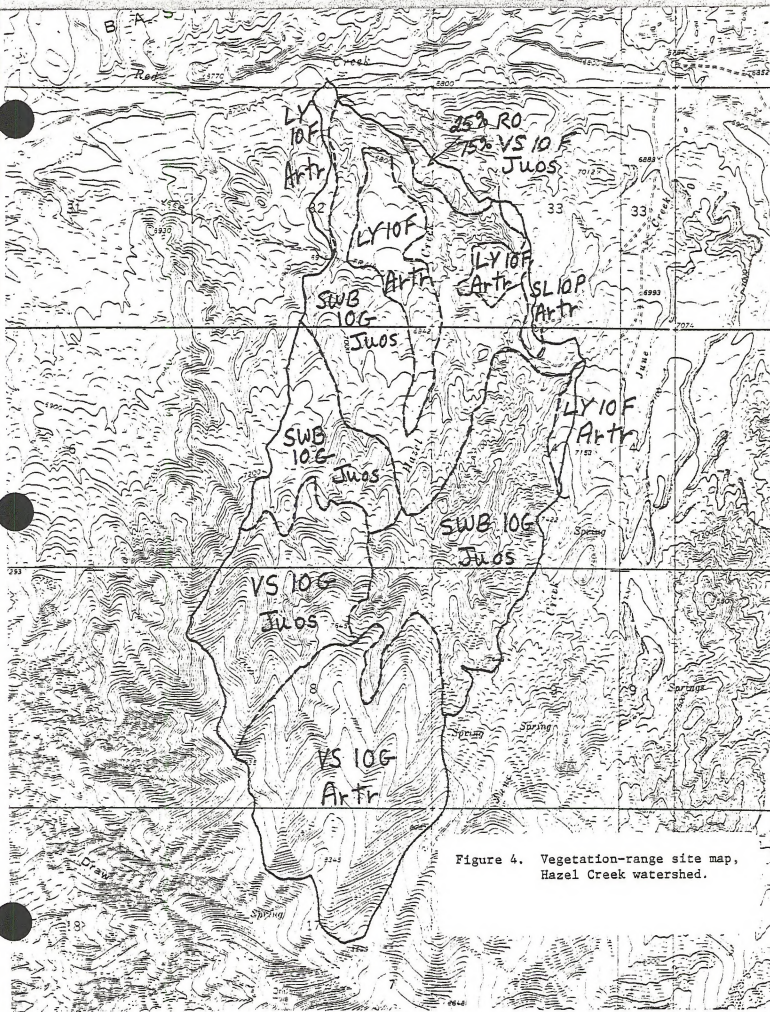


Figure 4. Vegetation-range site map, Hazel Creek watershed.



Sub- Drainage	Area (mi ²)	Average Land Slope (%)	Length of Longest Channel (ft)	Elevation Range (ft)
Hazel Creek at Dam	1.17	22	15,240	6,870-8,509
West Fork Hazel Creek at Small Dam	0.76	30	9,560	7,140-8,345
East Fork Hazel Creek	0.46	19	12,150	6,810-7,580
Hazel Creek at Meadow	0.67	27	5,680	7,200-8,509

HYDROLOGIC ANALYSIS

Precipitation Depth-Frequency Analysis

A precipitation depth-frequency curve for the six-hour duration storm was constructed from data presented in NOAA Atlas No. 2 for Wyoming. Selected points from the curve are tabulated below.

Precipitation Depth-Frequency Table for
6-hour Duration Storm, Red Creek, Wyoming

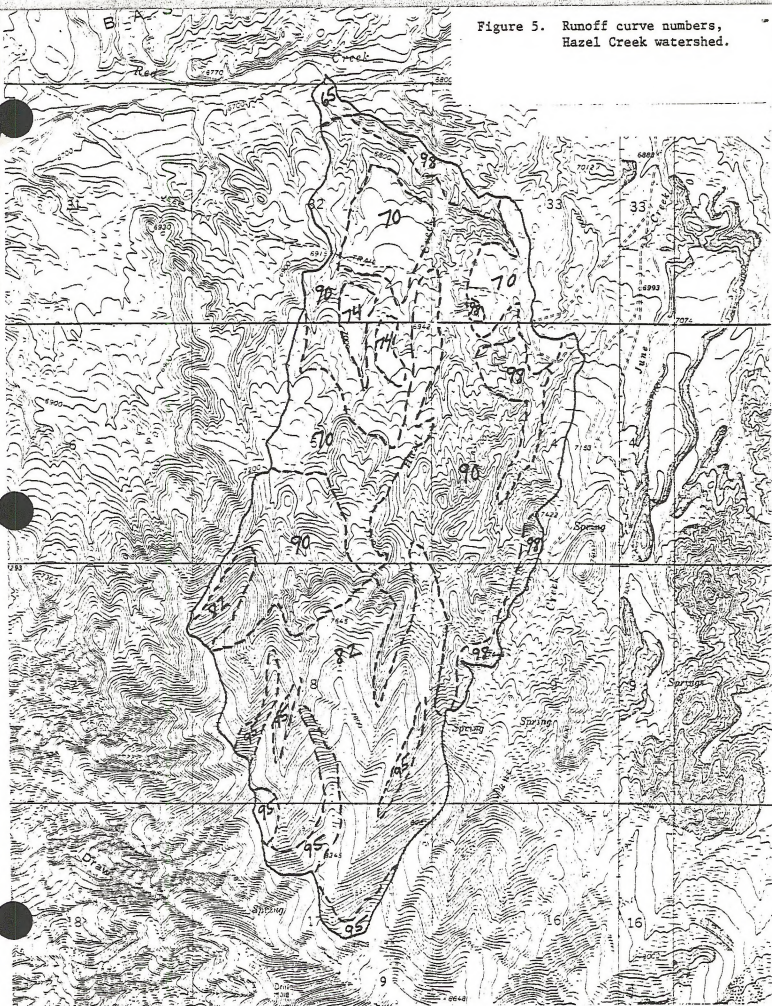
<u>Return Period, years</u>	<u>Precip. Depth, inches</u>
2	0.90
5	1.20
10	1.40
15	1.50
20	1.55
25	1.60
30	1.65
40	1.75
50	1.80
100	2.00

Runoff Curve Number Determination

The SCS procedure (SCS National Engineering Handbook, Chapter IV) was used to estimate storm runoff and peak discharges for selected storm depths in Hazel Creek. Curve number assignments were based on vegetation type, hydrologic soil group, hydrologic condition, and antecedent moisture condition (AMC). The curve number map (Fig. 5) shows curve numbers for AMC II. (See also color photos in Appendix A.) Area-weighted average curve numbers were computed for the four sub-drainages as follows:



Figure 5. Runoff curve numbers,
Hazel Creek watershed.





Erosion Rates and Sediment Delivery

Erosion condition was determined by visual analysis and by application of the Universal Soil Loss Equation (USLE) to representative land types in the Hazel Creek basin (Table 1). Sediment delivery ratios were used to route upland erosion to selected points in the channel system. Channel erosion was estimated as a fraction of surface erosion and sediment yield based upon estimates of the relative importance of channel erosion to total sediment yield. Erosion and sediment yield summaries are provided in Table 2.

Salinity Considerations

Soils and parent materials in parts of the Red Creek basin are very high in soluble salts. However, soils in Hazel Creek appear to be only slightly to moderately saline. Using a rule of thumb of roughly 1 percent soluble salts in slightly to moderately saline soils (USDI, 1978) and sediment yield data developed elsewhere in this report, a crude estimate of 70 tons of salt per year are yielded by Hazel Creek through erosion processes. This translates into roughly \$2,800 per year in downstream salinity costs using standard Bureau of Reclamation economic models (USDI, 1980). The salinity benefits associated with the projects under consideration in Hazel Creek are inconsequential, since no total runoff retention is anticipated and proposed erosion benefits are only a small fraction of the total basin sediment yield.

WATERSHED STABILIZATION PROJECT ALTERNATIVES

The following projects were considered and are discussed below (refer to Fig. 6 and color photos in Appendix A):

1. Maintain and raise existing dam on Hazel Creek main channel (SW 1/4, section 33, T 13 N, R 104 W.)
2. Control gully headcut at lower end of upper meadow on Hazel Creek main fork (SE 1/4, section 5, T 12 N, R 104 N).
3. Implement prescribed burn in upper meadow on Hazel Creek main fork (SE 1/4 Section 5 and NE 1/4 Section 8, T 12 N, R 104 W).
4. Maintain existing dam on West Fork Hazel Creek (SW 1/4 Section 5, T 12 N, R 104 W).
5. Realign channel and construct retention structures on East Fork Hazel Creek (SW 1/4 Section 33, T 13 N, R 104 W).
6. Realign and stabilize Hazel Creek main channel through upper meadow. (SE 1/4 section 5, NE 1/4 Section 8 and NW 1/4 Section 9, T 12 N, R 104 W).



Table 1. Representative USLE Calculations..

<u>Sub-area</u>	<u>R</u>	<u>K</u>	<u>LS</u>	<u>C</u>	<u>P</u>	<u>A (tons/acre/yr)</u>
Hazel Creek at Dam	20	0.40	2.6	.12	1	2.50
Hazel Creek at Meadow	20	0.25	5.0	.09	1	2.25
West Fork Hazel Creek	20	0.30	6.5	.04	1	1.14
East Fork Hazel Creek	20	0.40	5.0	.20	1	10.00

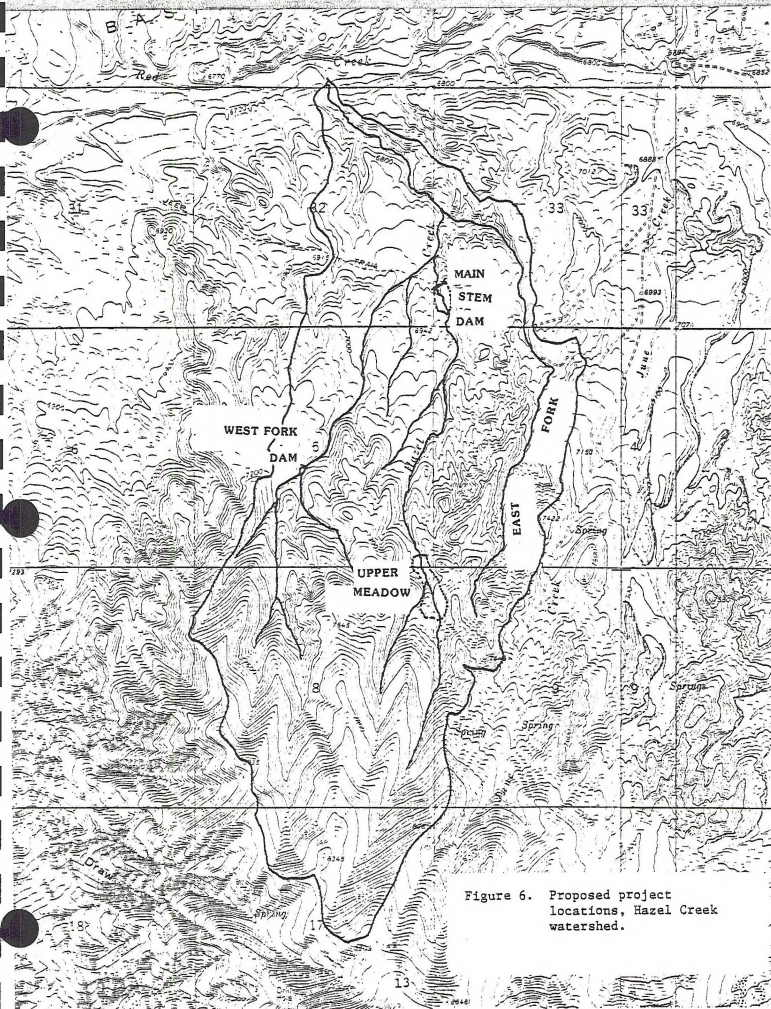
Table 2. Summary of Erosion and Sediment Yield.

<u>Sub-area</u>	<u>Area, (acres)</u>	<u>Average Soil Loss (tons/acre/yr)</u>	<u>Sediment Delivery Ratio*</u>	<u>Channel Erosion tons/yr**</u>	<u>Total Sediment Yield (tons/yr)</u>
Hazel Creek at Dam	749	2.50	.2	1,120	1,500
Hazel Creek at Meadow	429	2.25	.2	580	770
West Fork Hazel Creek	486	1.14	.2	330	440
East Fork Hazel Creek	294	10.00	.3	2,650	3,528

*estimated

**estimated as 3 times surface sediment yield.







Dam Maintenance and Enhancement, Hazel Creek Main Stem

The existing detention dam in the southwest corner of section 33 has filled with sediment and is breached. A spillway needs to be constructed to avoid further erosion of the dam and its accumulated sediments. In addition there is some potential to raise the effective height of the dam and provide additional sediment storage and extend the gully stabilizing effects of the dam both upstream and downstream. The hydrologic analysis for the spillway design flow is provided elsewhere in the report. A recommended design flow of 110 cfs should assure less than a 20 percent probability of failure in 50 years, after the structure has "silted in."

Although more detailed engineering analysis is required, a preliminary assessment is that an opportunity may exist to raise the effective height of the detention structure (see Fig. 7). Figure 8 summarizes benefits in terms of water detention and sediment storage for alternative increases in effective height of the dam. For example, increasing the effective height of the dam 5 feet will result in approximately six acre-feet of increased sediment storage capacity and will extend the channel stabilizing effects of the structure approximately 250 to 500 feet upstream.

Maximum water detention would be 6 acre-feet assuming a 5-ft increase in the effective dam height. Water detention capacity would be reduced over time due to sedimentation. The sediment delivery rate at the dam is approximately 30,000 ft³ per year. Assuming that the sediment trap efficiency at the dam decays linearly from 100% under empty conditions to 0% when full, a 5-ft. effective height dam would have a half life of 4.5 years and would be 90% full in 17 years.

Two crest-stage streamgages, for measuring peak flows below the dam, were installed in the main channel of Hazel Creek between the dam and the road crossing downstream. Cross sections at the gages and a long profile of the gaged reach are provided (Appendix B). A preliminary rating curve for the gaged reach, assuming a Manning's "n" value of 0.02 is provided in Appendix B. The stage value in the table is elevation above the zero datum in cross section #2.

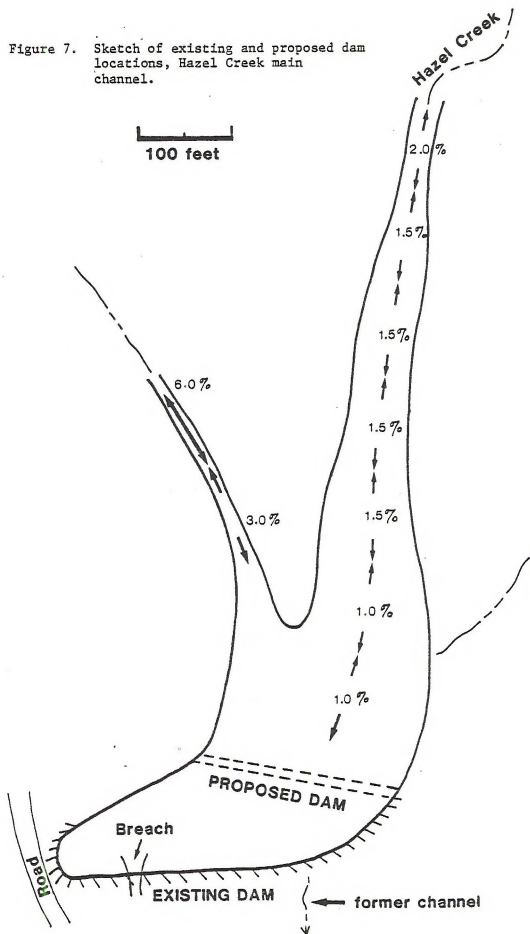
An additional crest-stage monitoring station is recommended in the main channel above the influence of the dam. This will enable a quantification of the effects of the dam on peak flows, and will provide a permanent monitoring station for changes in channel cross-sections.

Gabion Head Cut Control Structure, Upper Meadow, Hazel Creek Main Stem

Maccaferri River-type gabions are recommended for the gabion head cut structure. These gabions are heavily galvanized for the long life in flowing water. Maccaferri gabions are carried by Rocky Mountain Gabions, 650 17th St., Denver, Colorado 80202 (303-825-0271).



Figure 7. Sketch of existing and proposed dam locations, Hazel Creek main channel.





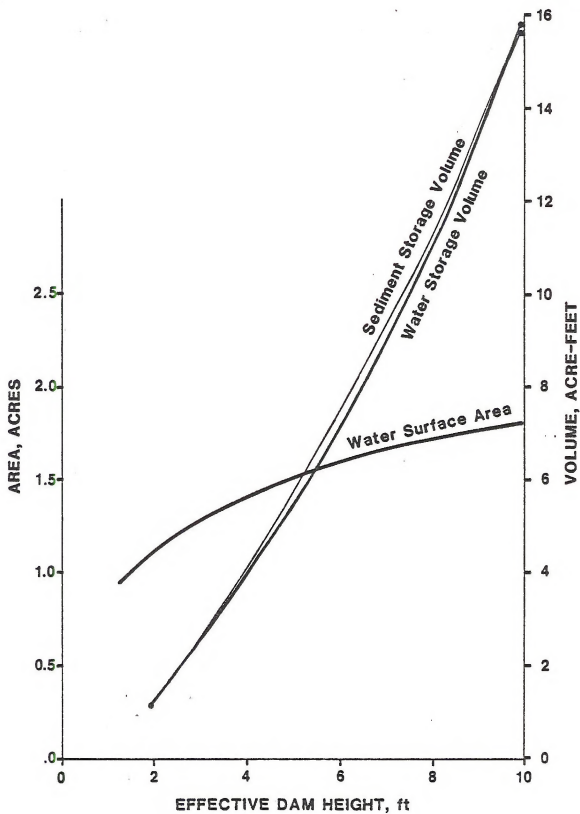


Figure 8. Water and sediment storage for various alternative increases in height of Hazel Creek.



The head cut control structure design is shown in Figure 9. The basic structure involves two three-foot drop steps, a six-foot by six-foot toe apron and an inlet control keyed into the channel bank six to nine feet behind the edge of the first step. The present head cut is more than six feet high, and it will be necessary to cut back the existing channel from the upper edge of the structure to the mouth of the existing gully upstream. This will result in a slight steepening and incising of the present channel upstream from the headcut. A steeper more incised channel through this reach will eliminate problems of sediment aggradation and channel migration. A gabion base control (9 ft X 3 ft by 1-1/2 ft) should be placed at the upper edge of the regraded channel to assure that gully deepening doesn't extend up into the meadow (see Fig. 10).

Total gabion rock requirements are estimated at 18 yards for the drop structure and 1 1/2 yards for the base control.

The suggested gabion design will carry a discharge of 90 cfs without being over-topped. The design discharge was calculated using hydraulic considerations of free overfalls (Henderson, 1966) and a maximum critical depth of 3 feet. This design discharge is well within the estimated 100-year discharge for Hazel Creek at the Upper Meadow.

Prescribed Burn - Hazel Creek Upper Meadow

This meadow is a highly productive site which has been invaded by sagebrush and rabbitbrush. A prescribed burn, having the objective of reducing or eliminating sage and rabbitbrush, should improve species desirable for livestock and wildlife. Watershed cover condition is expected to remain the same. This project is recommended for immediate implementation, depending on weather conditions.

Maintenance of Existing Dam on West Fork Hazel

This structure has filled with sediment to the level of the spillway. The spillway appears to be functioning adequately. However, it has been several years since the West Fork has experienced a significant rainfall-runoff event.

We recommend no action be taken at this time, other than periodic inspection of the structure and stream channels above and below the site. If conditions warrant at a later date, the capacity of the structure could be restored and the spillway improved.

East Fork Channel Realignment and Detention Structure

Many years ago the East Fork of Hazel Creek jumped from its existing channel and cut a new channel to the west (see Fig. 11). Previously, the East Fork flowed directly to Red Creek. Today it joins main Hazel Creek before reaching Red Creek. This channel alteration was a significant hydrologic event for two reasons. First, the new channel became incised in very erosive soils.



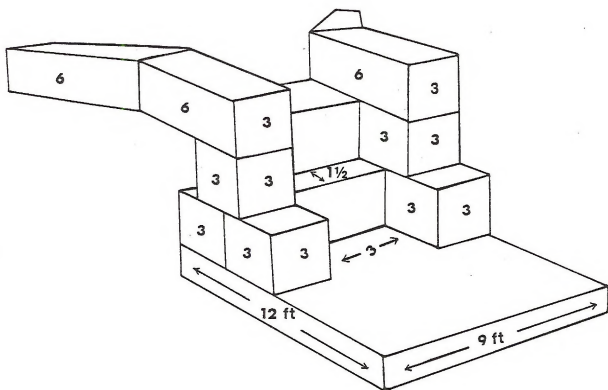


Figure 9. Perspective view, gabion head cut control,
upper meadow, Hazel Creek main stem.



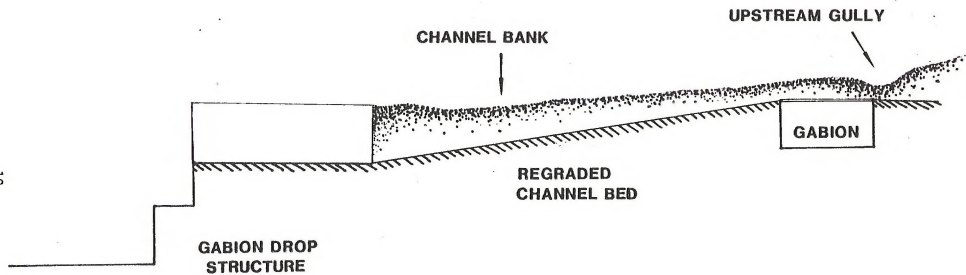
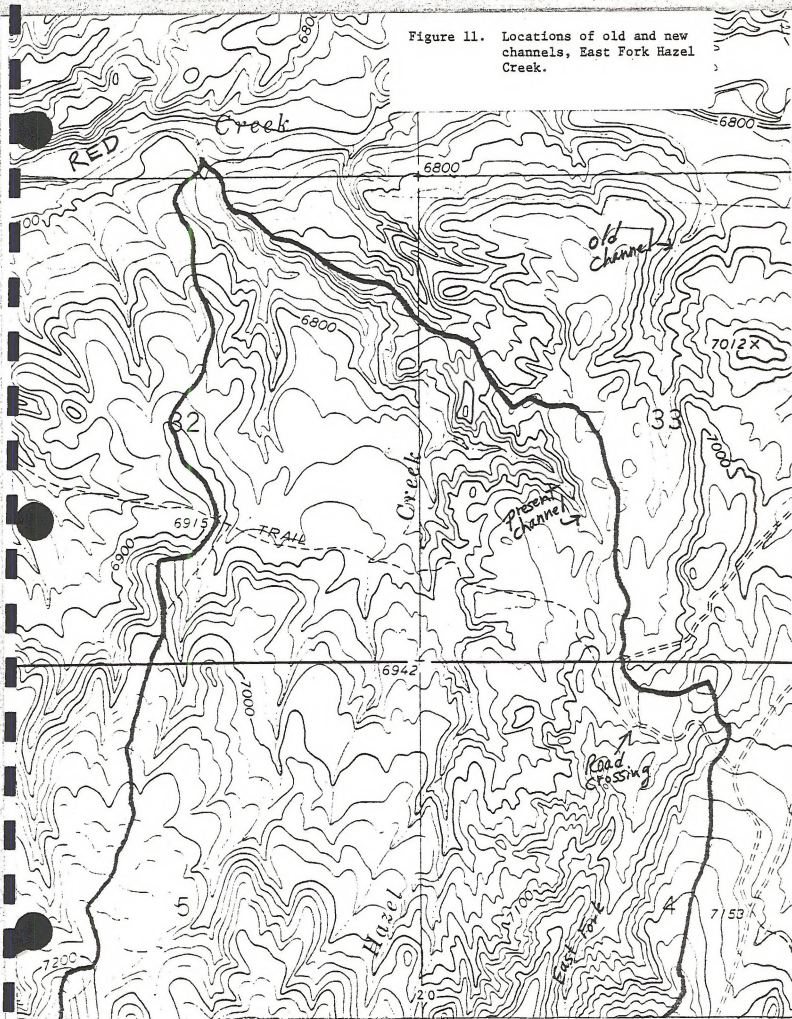


Figure 10. Side view, gabion drop structure, regraded channel bed, and upstream gabion base level control.



Figure 11. Locations of old and new channels, East Fork Hazel Creek.





Secondly, the new channel has a steeper gradient than the previous channel (230 feet/mi as opposed to 175 ft/mi). The result very likely has been a significantly larger sediment load being delivered downstream. A minor realignment of the channel together with a system of retention structures and dike-waterspreaders could control most if not all the water and sediment produced by the East Fork. Increased forage production would also result. These structures could be located on the sagebrush flat below the East Fork road crossing.

This project is not recommended for implementation at this time. It would be costly to implement due to the large volumes of material to be moved. The benefit-cost ratio of this project would not be as favorable as for the other projects and therefore should be considered lower priority. However, if manpower and funds allow, the site should be surveyed and a detailed project feasibility completed.

Channel Realignment - Hazel Creek Upper Meadow

The existing gully in the Upper Meadow of Hazel Creek has resulted in the elimination of any irrigation benefits from streamflow in the main channel. It has also steepened hydraulic gradients and caused groundwater flow originating in springs alongside and under the meadow alluvium to be more quickly drained to the channel system. The prescribed head-cut control is a minimum action required to prevent further downcutting of the gully. Because of the scattered springs and seeps in the lower portion of the Upper Meadow, it was felt that site productivity was sufficiently high so as not to warrant additional actions to repair the existing gully. However, an opportunity exists to relocate the main channel of Hazel Creek from the gully to the meadow surface east of the existing channel. Benefits would be increased irrigation of the meadow and subsequent improved forage production. In addition, it is probable that some riparian-type wet habitat would result along the new stream channel.

A channel realignment in the Upper Meadow could be accomplished by cutting off the main channel just below the confluence with the west stem of the main channel and moving the stream approximately 50 to 100 feet over to the site of a former meadow channel. The new channel would have to be reconstructed to be a wider shallow stream channel. Gabion base controls would need to be located at 100 to 200 feet intervals to insure that a new gully would not result. The new channel would be discharged over the meadow lip at the proposed gabion head-cut control.

This project is not recommended for immediate implementation. The headcut control and channel stability in the meadow should be monitored for two to three years before further actions are planned.

Appendix C provides profile data for the lower portion of the Upper Meadow.



Other Considerations

The channels of the West Fork, East Fork and main stem of Hazel Creek were searched using air photos and checked in the field for detention dam and gully plug sites. Because of the steep channel gradients, no suitable sites were found.

Consideration was given to mechanically treating highly erodible soils. No suitable sites were found for this type of treatment. Sites where improved infiltration would be desirable are generally located on the very steep slopes. Disturbance to these sites could actually accelerate soil erosion.



LITERATURE CITED

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- USDA, Soil Conservation Service. 1972. National Engineering Handbook, Chapter 4.
- USDA, Soil Conservation Service. 1979. Erosion in Red Creek watershed, Wyoming. Casper, Wyoming.



Appendix A

Color Photos





Photo A1

Headwater area, Hazel Creek main stem. Most of this area mapped as CN = 82. Rock outcrops on ridges and sparsely-vegetated steeper slopes were mapped as CN = 95.

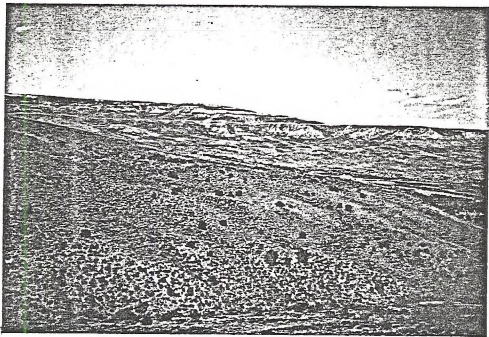


Photo A2

These sparsely-vegetated areas in the middle of Hazel Creek watershed were mapped as CN = 95.



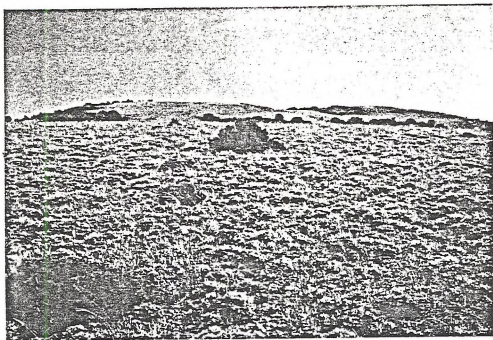


Photo A3

Very shallow range site (VS 10G) dominated by sagebrush,
upper West Fork of Hazel Creek.

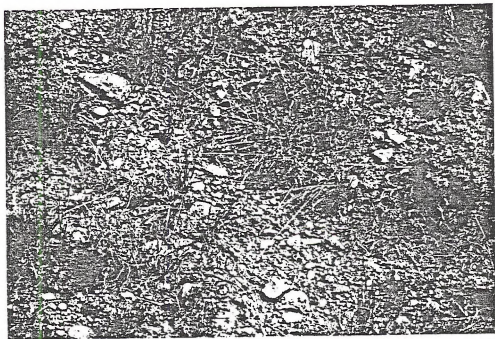


Photo A4

Very shallow range site (VS 10G) dominated by sagebrush-
grass cover type (runoff curve number = 70).



71231-01



Photo A5

Lower portion of East Fork of Hazel Creek watershed.

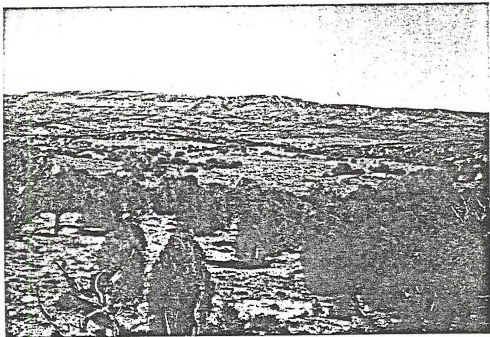


Photo A6

Lower portion of East Fork drainage, Hazel Creek. Sagebrush area was mapped as loamy range site (LY 10F), with a CN of 70. Juniper type was mapped as shallow breaks range site (SWB 10G) with a CN of 90.



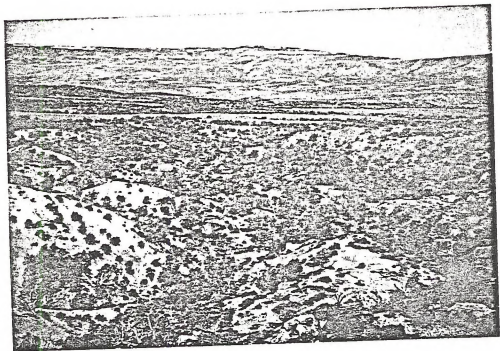


Photo A7

Badlands landscape, East Fork of Hazel Creek watershed.
This is typical of badlands areas mapped as CN = 98.

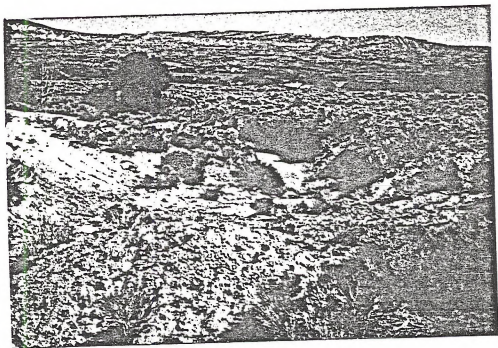


Photo A8

Road crossing, East Fork of Hazel Creek. showing gully
development in new channel.



Photo A9

Dam on Hazel Creek main stem showing breach.



Photo A10

Sediment deposition behind Hazel Creek dam.





Photo A11 Location of proposed Hazel Creek dam enhancement.

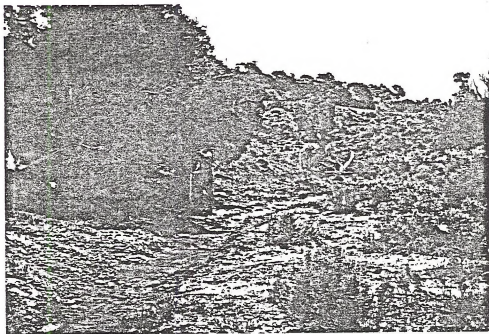


Photo A12 . Crest-stage gages #1 and #2 below dam on Hazel Creek main stem.





Photo A13

Headcut on Hazel Creek main stem, lower end of upper meadow.

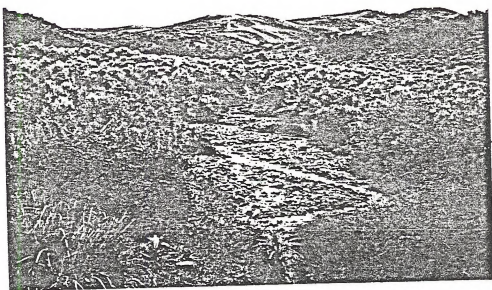


Photo A14

Hazel Creek main stem channel above headcut, lower end of upper meadow.



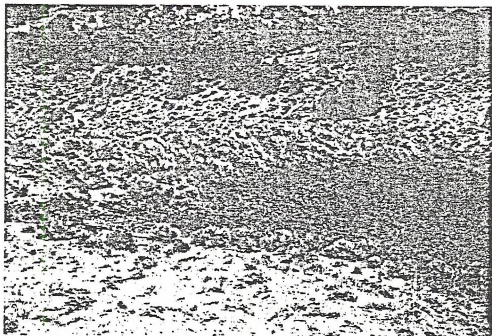


Photo A15 Small dam on West Fork of Hazel Creek.

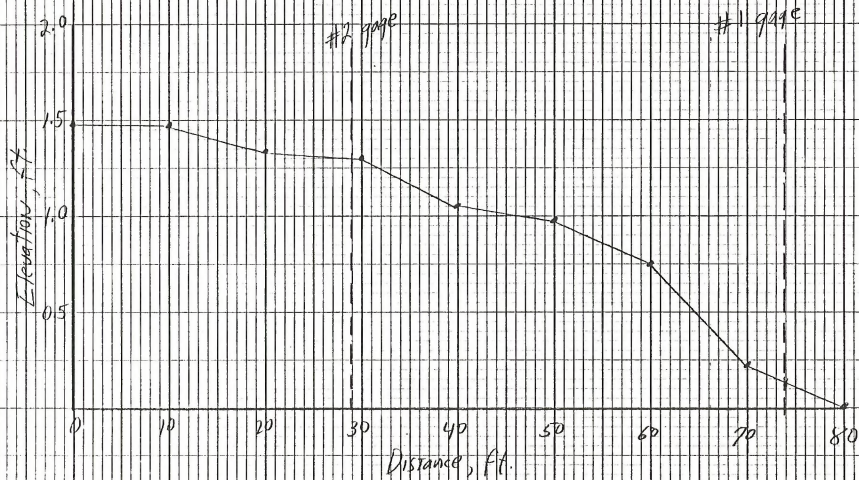


Appendix B

Survey and Hydraulic Data for Crest-Stage Gages



HAZEL CREEK CREST STAGE GAGES:
LONG PROFILE





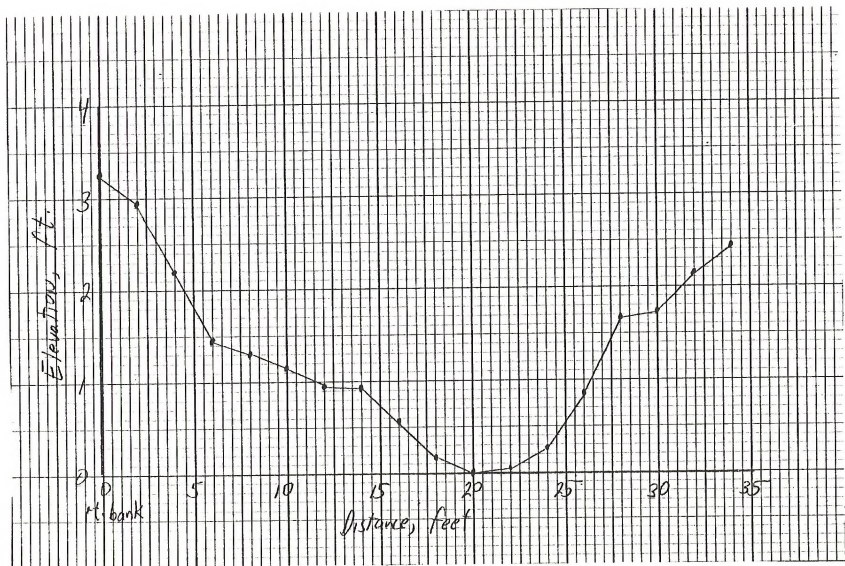
HAZEL CREEK CREST STAGE GAGE:
X - SEC. 1 PROFILE





HAZEL CREEK CREST STAGE GAGE:
X - SEC. 2 PROFILE

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Rating Curve at Crest Stage Cross Section #2 for Manning's
"n" value of 0.02.

			X-SECT	WETTED	HYDR	TOP
STAGE	DISCH	VEL	AREA	PERIM	RADIUS	WIDTH
0.010	0.001	0.266	0.003	0.512	0.005	0.511
0.183	1.218	2.108	0.578	5.185	0.111	5.169
0.356	5.692	3.423	1.663	7.206	0.231	7.156
0.529	13.605	4.495	3.027	8.719	0.347	8.628
0.701	24.970	5.375	4.645	10.233	0.454	10.100
0.874	40.065	6.146	6.518	11.743	0.555	11.568
1.047	55.066	6.227	8.843	15.621	0.566	15.399
1.220	76.901	6.513	11.808	19.502	0.605	19.235
1.393	112.004	7.337	15.266	21.085	0.724	20.772
1.566	154.897	8.165	18.972	22.323	0.850	21.953
1.739	195.439	8.531	22.909	25.238	0.908	24.810
1.911	253.373	9.280	27.303	26.513	1.030	26.034
2.084	318.420	9.979	31.909	27.788	1.148	27.259
2.257	388.647	10.579	36.737	29.307	1.254	28.732
2.430	464.070	11.087	41.857	31.123	1.345	30.504

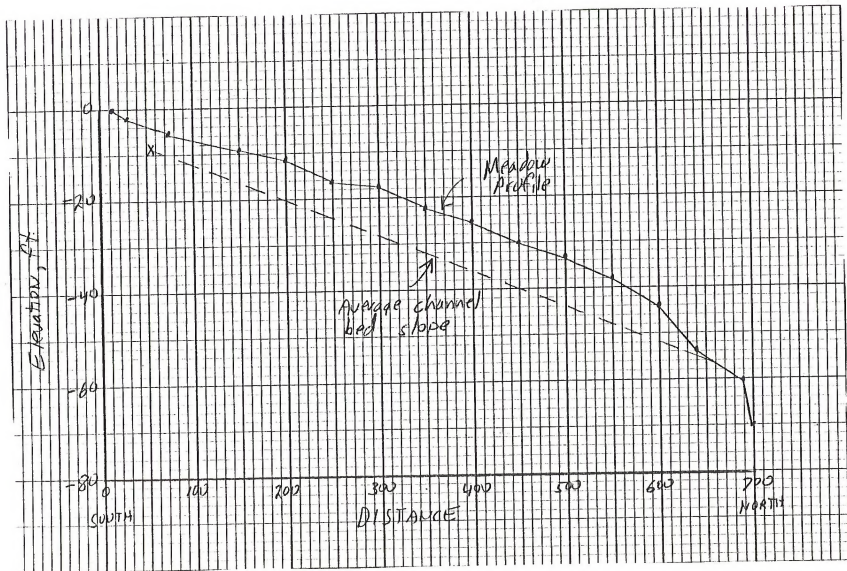


Appendix C

Survey Data, Upper Meadow



UPPER MEADOW, HAZEL CREEK:
LONG PROFILE

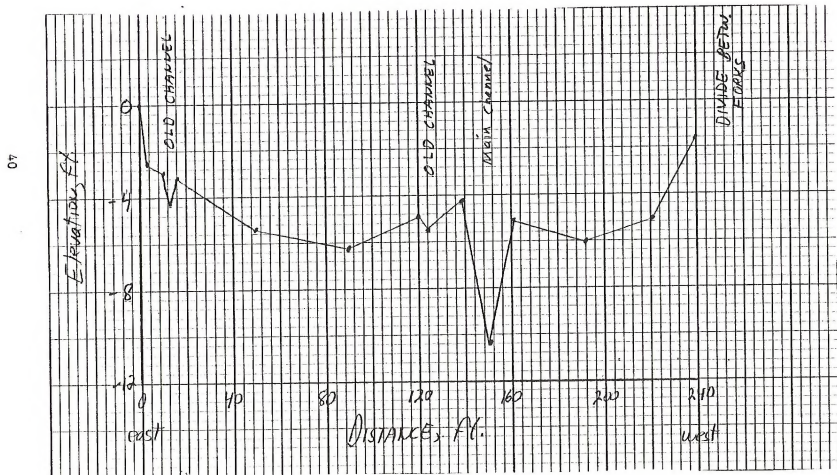




UPPER MEADOW, HAZEL CREEK:

X - SEC. 1

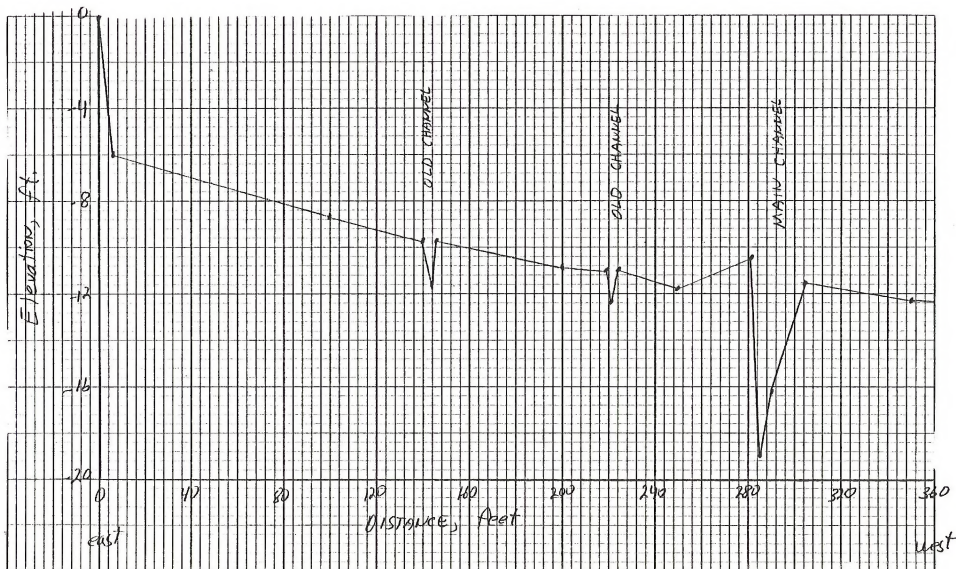
@ 73 FT. ON LONG PROFILE





UPPER MEADOW, HAZEL CREEK:
X - SEC #2
@ 450 FT. ON LONG PROFILE

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2018. 10. 10



UPPER MEADOW, HAZEL CREEK:
X - SEC. #3
@ 590 FT. ON LONG PROFILE

